Observational Analysis of Operational Capabilities at McMurdo Station, Antarctica through both fieldwork and Study of Upper Air Data

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Background and History of McMurdo Station

McMurdo Station was founded in 1956 and named after Lieutenant Archibald McMurdo of the ship *Terror.* Over the years the U.S. Navy's role has included :

- 1946 "Operation Highjump" was launched to prepare troops for polar conditions and have presence in Antarctica using four diesel submarines
- 1947-1955 : expanded the knowledge for future submarine forces and capabilities under ice
- 1955-1958 : Operation Deepfreeze where permanent station (McMurdo Station) was constructed by the Seabee's
- 1998 : Navy officially withdrew from operations and Air Force took over responsibility for flight operations (current)

McMurdo Statistics

McMurdo is located on the volcanic rock of Hut Point Peninsula of Ross Island,1.5 sq. mi. between Hut Point and Observation Hill seen in Figure 1 below. The main transportation in and out of McMurdo from Christchurch and other camps are the C-130's and C-17's (109th Airlift Wing, Air Force National Guard)

The current focus in McMurdo is science research through the United States Antarctic Program and National Science Foundation. The largest building on the station is Crary Lab comprising 8.81 sq.mi of working space.



Figure 1 : Aerial View from Observation Hill with Hut Point in the distance (left picture). Chapel of the snows (Top right picture). Chow Hall in blue with Observation Hill in the background (bottom right picture).

Flight Operations

The purpose of the109th Airlift Wing, Air Force National Guard, stationed in New York is to provide airlift support to the National Science Foundation for research. The aircraft are flown from New York to Christchurch, NZ to McMurdo Antarctica in October and depart McMurdo before the Southern Hemisphere winter season in March. The crew of 130 are responsible for cycling through the 1,200 people that McMurdo can accommodate in the summer season, transporting cargo and fuel to remote field research camps (figure 2, B) and evacuating people for medical emergencies (figure 2, A).

On average there are 3,000 flight missions in one season. This provides a very demanding schedule for the crew. The biggest challenge is the flight schedule and the weather impacts to ensure safe flying.



Figure 2 : Medical Evacuation mission due to a scientist with kidney failure (A). Off loading fuel and cargo to camp sights in the Central Transantarctic Mountains(B) Me as the acting co-pilot over the Ross Sea (C)

Weather Challenges, Flight Missions, and Experiences on the Ice 2011

After my 12 days on the ice I was able to spend significant time in the weather center (figure 3,A), the flight operations center (figure 3,B) and the aircraft. Below are two examples of when flight operations were affected by weather.

1) Biggest impact on science 2012 season was the success on Pine Island Glacier (PIG) study on ocean-ice interaction beneath the glacier and impact of sea level rise due to warm currents melting ice. Due to poor weather in Byre (midway point from McMurdo to PIG) the flight never left McMurdo and the research was terminated

2) Personally, my flight to leave the Continent was delayed three days due to unfavorable weather and I finally left with the crew on an emergency medical evacuation missions (figure 2, A).

The main forecasting challenges are the harsh climate, rapid weather changes, limited data sources, and minimal emergency landing locations. T0 help with these challenge 20 satellite pictures a day are sent to the weather station from the National Ice Center, Automatic Weather Stations (AWS) are stationed throughout the area, and weather soundings.

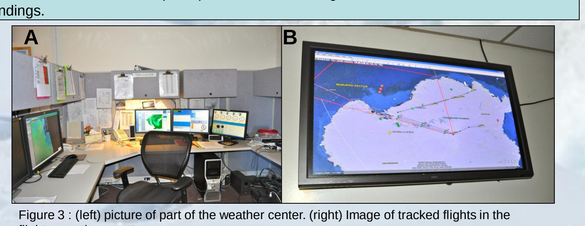


Figure 3 : (left) picture of part of the weather center. (right) Image of tracked flights in the flight operations center

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Data Collection at McMurdo Station, both Surface and Upper Air

Aquiring Upper Air Data

At McMurdo weather data is collected and recorded daily through weather balloons and AWS units.

During my trip I partook in two methods of acquiring weather data.

1) I Released a weather balloon (figure 4 and 6)

2) I took a snowmobile trip to the side of Mt. Erabus where there were multiple AWS units (figure 5, A and B). AWS units helps fill the gaps of surface weather data in areas with sharp topography (Pegasus runway). Currently 68 AWS units on the Continent.



Figure 4 : Release of the weather balloon radiosonde with Hut Point in the background. Weather balloon was launched 25 December 2011, 12Z

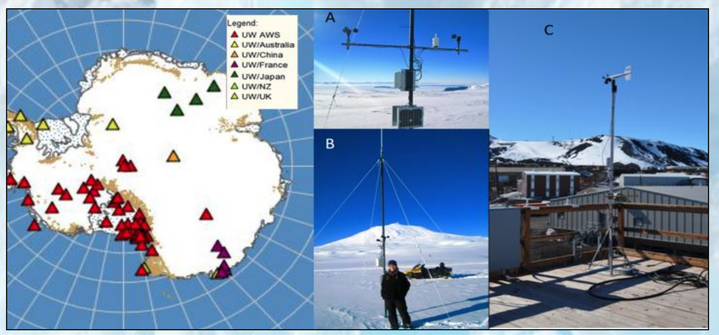


Figure 5 : (Right) Map of the current Automatic Weather Stations (AWS) compliments of University of Wisconsin-Madison and the AWS Project. (A and B) AWS stations I saw on a snowmobile trip with Mt.Erebus in the background. © AWS on the roof of the weather forecasting center used for visual observations

Methodology of a Weather Balloon release in McMurdo

A weather balloon is launched twice a day in the Southern Hemisphere summer months and once a day in the winter months. The radiosonde collects temperature, pressure, dew point, and both wind speed and direction. Below are the steps that explain how to launch a weather balloon (Figure 6 to the right).

A)Retrieve the balloon from the heated cabinet

B)Unpackage the balloon making sure you only touch the bottom opening and not the balloon itself

C)Turn on the helium to fill the balloon

D)Wait for the balloon to fill

E)The balloon is at its maximum fullness when the 50 gram weight is lifted from the table

F)The helium is shut off

G)The radiosonde package is tied to the bottom of the balloon

H)Call McMurdo Air Traffic Control Center to make them aware that you are launching the balloon

I)Release the balloon which will journey up to about 70,000 feet at McMurdo. Some may go to 113,000 feet in warmer climates.



Figure 6 : visual mages for the steps to launch a weather balloon.

Data Used for the Purpose of this Project

For the purpose of this project I choose to examine 850 mb and 500 mb data for the month of December from 1999-2011. I used 850 mb to serve as the surface level data because 1000 mb had too much missing data. The 500 mb level data was used to examine the mid-troposphere trends. The month of December was analyzed because that was the month I visited the Continent.

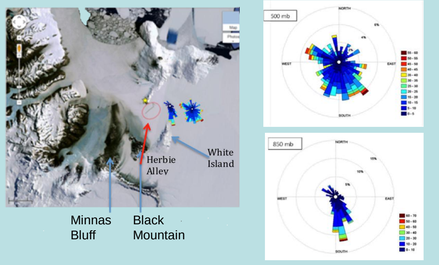


Figure 7 : The leftward picture is a compliments of googlemap, showing the topography if the Pegasus runway (circled in red) that is to the right of McMurdo station (yellow star). The images to the right are wind rose plots that were created using MATLAB with the 850 mb and 500 mb data.

Wind Rose Plots

The direction and speed of the wind is very important to pilots and their flight operations. 70% of wind at McMurdo is from the East for 850 mb. This is important for takeoff and landing. Since the wind is aligned with the runway the aircraft can fly into the wind in order to get lift. Strong surface winds through Herbie Alley can be dangerous for flight operations if it becomes a crosswinds.

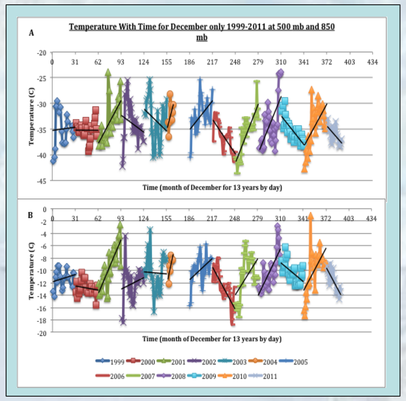


Figure 8 : Temperature trends for the month of December for 1999-2011 for 850 mb (A) and 500 mb (B).

Climatology at 850 mb and 500 mb, December 1999-2011

During the 13 year investigation the trends vary from no significant slope, upward slope, and downward slope. The graphs in Figure 8 captures the trends that are separated by year. A challenge was accounting for the missing data in 2004.

Due to the short time series of this data set no significant conclusions can be drawn. Further studies will focus on all months in the Southern Hemispheres winter season.

Climatological Analysis Using Upper Air Data from Soundings

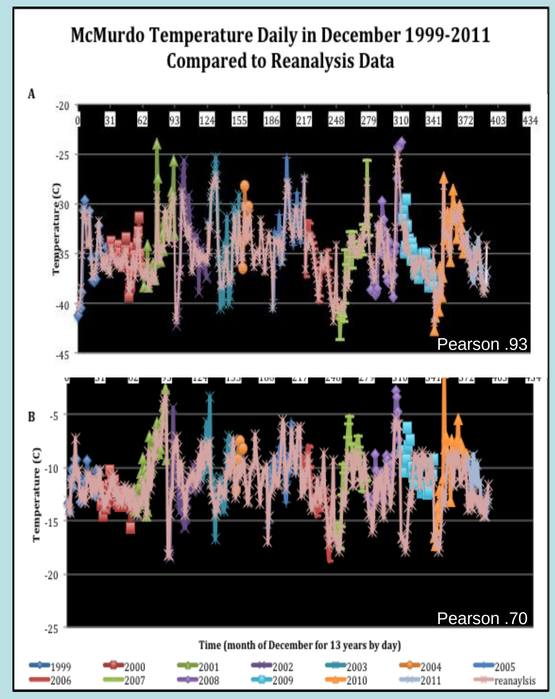


Figure 9 : Above is the comparison of the McMurdo radiosonde data compared to the NCEP reanalysis data in pink.

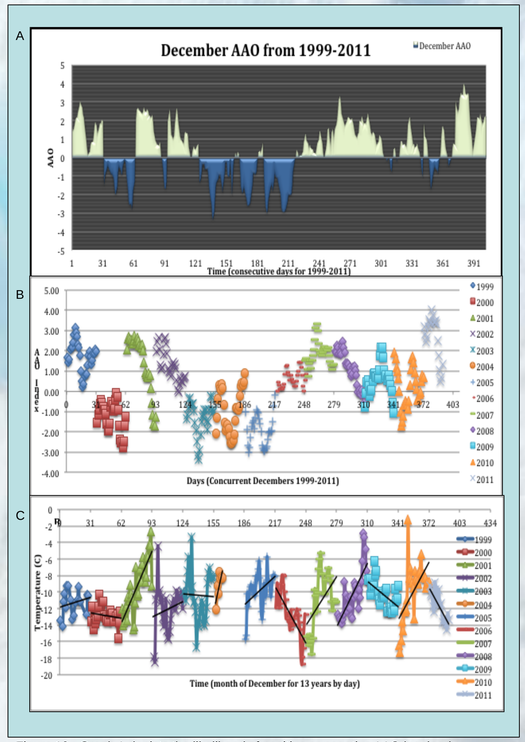


Figure 10 : Graph A depicts the likelihood of positive or negative AAO by clearly marked area. Graph B shows the AAO data separated by year. Graph C is the McMurdo temperature data separated by year.

Comparison of McMurdo data and NCEP Reanalysis Data

NCEP reanalysis data uses a combination of several different types of weather information to compile an overall trend for a specific labeled area, referred to as a grid box. The grid box used for this data was 77.5 S and 167.5E. Again, with the challenge of missing McMurdo data, the NCEP data for those days were removed from the data set to ensure an accurate correlation. Once the data was plotted, the trends became evidence and the reanalysis data validated the McMurdo weather balloon data as the trends are similar with less extreme maximums and minimums.

A pearson correlation (figure 9) was used to determine exactly how closely the data sets related. The 500 mb had a stronger correlation than surface 850 mb data which is validated by unique topography at McMurdo that pronounces the surface weather extremes.

Association with Large Scale Circulation, the AAO

The Antarctic Oscillation (AAO) is the difference in sea level pressure between 40 degrees and 65 degrees South. The AAO depicts the tendencies of the atmosphere in Antarctica and I wanted to see if the McMurdo data related to the state of the atmosphere. A positive AAO is associated with high pressure difference and results in stronger westerly circumpolar flow which advert water flow from the lower latitude, cooling the Continent and thicker ice. A negative AAO is associated with low pressure difference which results in warmer temperatures. The AAO data is collected at 700 mb, therefore 850 mb McMurdo data was used as a comparison. The results confirmed that temperatures decreased during the positive AAO, while temperatures increased during the negative AAO. Further studies will examine the S.H. winter months.